

WHAT IS CLAIMED IS:

1. An apparatus which performs a plasma process on a target substrate by using plasma, comprising:
 - an airtight process chamber which accommodates the target substrate;
 - a gas supply system which supplies a process gas into the process chamber;
 - an exhaust system which exhausts an interior of the process chamber and sets the interior of the process chamber to a vacuum state;
 - first and second electrodes arranged in the process chamber to oppose each other, an RF field, which turns the process gas into plasma by excitation, being formed between the first and second electrodes;
 - an RF power supply which is connected to the first or second electrode through a matching circuit and which supplies RF power, the matching circuit serving to automatically perform input impedance matching relative to the RF power;
 - an impedance setting section which is connected, through an interconnection, to a predetermined member to be electrically coupled with the plasma in the plasma process, and which sets a backward-direction impedance as an impedance against an RF component input from the plasma to the predetermined member, the impedance setting section being capable of changing a value of the backward-direction impedance; and

a controller which supplies a control signal concerning a preset value of the backward-direction impedance to the impedance setting section.

2. The apparatus according to claim 1, wherein
5 the controller further comprises a storage which stores data concerning a correlation between first and second processes having different conditions and first and second preset values, corresponding to the first and second processes, of the backward-direction impedance,
10 and the controller supplies to the impedance setting section a control signal which changes the backward-direction impedance from the first preset value to the second preset value on the basis of the data when a process to be performed in the process chambers
15 changes from the first process to the second process.

3. The apparatus according to claim 1, wherein the preset value is set in advance such that a planar uniformity of the plasma process on the target substrate is improved.

20 4. The apparatus according to claim 1, wherein the preset value is set in advance such that the plasma stabilizes.

25 5. The apparatus according to claim 1, wherein the plasma processing apparatus is an etching apparatus, the target substrate has a mask layer having a pattern and a lower layer to be etched which is under the mask layer, and the preset value is so set in

advance as to control a size to be processed of the lower layer.

6. The apparatus according to claim 1, wherein
the impedance setting section comprises one or both of
5 an arrangement which continuously changes the backward-
direction impedance with a continuous variable element,
and an arrangement which changes the backward-direction
impedance stepwise by switching a plurality of fixed
elements.

10 7. The apparatus according to claim 1, wherein
the impedance setting section comprises a function
which displays the preset value.

15 8. The apparatus according to claim 1, wherein
the controller or the impedance setting section
corrects the preset value with calibration data
that compensates for a difference intrinsic to the
impedance setting section, and then adjusts the
backward-direction impedance.

9. The apparatus according to claim 1, wherein
20 the RF power supply is connected to the first electrode
through a first interconnection, the impedance setting
section is connected to the second electrode through
a second interconnection, and the RF component includes
a fundamental frequency of the RF power.

25 10. The apparatus according to claim 1, wherein
the RF power supply and the impedance setting section
are connected to the first electrode through a first

interconnection, and the RF component includes a harmonic of a fundamental frequency of the RF power.

11. The apparatus according to claim 10, wherein
the value of the input impedance is so set by the
5 impedance setting section as to be not less than twice
a value of an RF load impedance formed by the process
chamber and the plasma against the RF power.

12. An apparatus which performs a plasma process
on a target substrate by using plasma, comprising:
10 an airtight process chamber which accommodates the
target substrate;
 a gas supply system which supplies a process gas
into the process chamber;
 an exhaust system which exhausts an interior of
15 the process chamber and sets the interior of the
process chamber to a vacuum state;
 first and second electrodes arranged in the
process chamber to oppose each other, an RF field,
which turns the process gas into plasma by excitation,
20 being formed between the first and second electrodes;
 an RF power supply which is connected to the first
or second electrode through a matching circuit and
which supplies RF power, the matching circuit serving
to automatically perform input impedance matching
25 relative to the RF power;
 an impedance setting section which is connected,
through an interconnection, to a predetermined member

to be electrically coupled with the plasma in the plasma process, and which sets a backward-direction impedance as an impedance against one of a plurality of different higher harmonics relative to a fundamental frequency of the RF power input from the plasma to the predetermined member, the impedance setting section being capable of changing a value of the backward-direction impedance; and

10 a controller which supplies a control signal concerning a preset value of the backward-direction impedance to the impedance setting section.

13. The apparatus according to claim 12, wherein the predetermined member is selected from the first and second electrodes and the process chamber.

15 14. The apparatus according to claim 12, wherein the predetermined member comprises a focus ring disposed to surround the target substrate.

15. The apparatus according to claim 12, wherein the predetermined member comprises a rectifying plate 20 disposed between a process space in the process chamber and an exhaust path.

25 16. The apparatus according to claim 12, wherein the impedance setting section comprises one or both of an arrangement which continuously changes the backward-direction impedance with a continuous variable element over the plurality of different higher harmonics, and an arrangement which changes the backward-direction

impedance stepwise by switching a plurality of fixed elements.

17. The apparatus according to claim 12, wherein
the impedance setting section has a filter to select
5 a higher harmonic as a resonance target.

18. The apparatus according to claim 17, wherein
the filter has a high impedance of not less than
50Ω against harmonics other than a selected harmonic.

19. The apparatus according to claim 17, wherein
10 the filter comprises a filter selected from the group
consisting of a high-pass filter, bandpass filter,
low-pass filter, and notch filter.

20. The apparatus according to claim 17, wherein
the filter cuts a component having the fundamental
15 frequency of the RF power.

21. An apparatus which performs a plasma process
on a target substrate by using plasma, comprising:

an airtight process chamber which accommodates the
target substrate;

20 a gas supply system which supplies a process gas
into the process chamber;

an exhaust system which exhausts an interior of
the process chamber and sets the interior of the
process chamber to a vacuum state;

25 first and second electrodes arranged in the
process chamber to oppose each other, an RF field,
which turns the process gas into plasma by excitation,

being formed between the first and second electrodes;

first and second interconnections which are respectively connected to the first and second electrodes and which extend to an outside of the process chamber, the first and second interconnections forming part of an AC circuit including electrical coupling between the first and second electrodes;

5 a first RF power supply which is arranged on the first interconnection and which supplies first RF power;

10 a first matching circuit which is arranged on the first interconnection between the first electrode and the first RF power supply and which automatically performs input impedance matching relative to the first RF power;

15 an impedance setting section which is arranged on the second intersection and which sets a backward-direction impedance as an impedance against an RF component input from the plasma to the second electrode, the impedance setting section being capable of changing a value of the backward-direction impedance, and the RF component including a component having a fundamental frequency of the first RF power;

20 and

25 a controller which supplies a control signal concerning a preset value of the backward-direction impedance to the impedance setting section.

22. The apparatus according to claim 21, wherein
the second interconnection is grounded through the
impedance setting section.

23. The apparatus according to claim 21, further
5 comprising:

a second RF power supply which is arranged on the
second interconnection and which supplies second RF
power; and

10 a second matching circuit which is arranged on
the second interconnection between the second electrode
and the second RF power supply and which automatically
performs input impedance matching relative to the
second RF power.

24. The apparatus according to claim 23, wherein
15 the first RF power has a frequency higher than that of
the second RF power.

25. The apparatus according to claim 23, wherein
the first RF power has a frequency lower than that of
the second RF power.

20 26. An apparatus which performs a plasma process
on a target substrate by using plasma, comprising:

an airtight process chamber which accommodates the
target substrate;

25 a gas supply system which supplies a process gas
into the process chamber;

an exhaust system which exhausts an interior of
the process chamber and sets the interior of the

process chamber to a vacuum state;

first and second electrodes arranged in the process chamber to oppose each other, an RF field, which turns the process gas into plasma by excitation,

5 being formed between the first and second electrodes;

first and second interconnections which are respectively connected to the first and second electrodes and which extend to an outside of the process chamber, the first and second interconnections forming part of an AC circuit including electrical

10 coupling between the first and second electrodes;

a first RF power supply which is arranged on the first interconnection and which supplies first RF power;

15 a first matching circuit which is arranged on the first interconnection between the first electrode and the first RF power supply and which automatically performs input impedance matching relative to the first RF power;

20 an impedance setting section which is arranged on the first intersection and which sets a backward-direction impedance as an impedance against an RF component input from the plasma to the first electrode, the impedance setting section being capable of changing

25 a value of the backward-direction impedance, and the RF component including a harmonic of a fundamental frequency of the first RF power; and

a controller which supplies a control signal concerning a preset value of the backward-direction impedance to the impedance setting section.

27. The apparatus according to claim 26, wherein a
5 value of the input impedance is so set by the impedance
setting section as to be not less than twice a value of
an RF load impedance formed by the process chamber and
the plasma against the first RF power.

28. The apparatus according to claim 26, further
10 comprising:

a second RF power supply which is arranged on the
second interconnection and which supplies second RF
power; and

15 a second matching circuit which is arranged on
the second interconnection between the second electrode
and the second RF power supply and which automatically
performs input impedance matching relative to the
second RF power.

29. The apparatus according to claim 28, wherein
20 the first RF power has a frequency higher than that of
the second RF power.

30. The apparatus according to claim 29, wherein
the first RF power has a frequency lower than that of
the second RF power.

25 31. An apparatus which performs a plasma process
on a target substrate by using plasma, comprising:

an airtight process chamber which accommodates

the target substrate;

a gas supply system which supplies a process gas into the process chamber;

5 an exhaust system which exhausts an interior of the process chamber and sets the interior of the process chamber to a vacuum state;

10 first and second electrodes arranged in the process chamber to oppose each other, an RF field, which turns the process gas into plasma by excitation, being formed between the first and second electrodes;

15 first and second interconnections which are respectively connected to the first and second electrodes and which extend to an outside of the process chamber, the first and second interconnections forming part of an AC circuit including electrical coupling between the first and second electrodes;

a first RF power supply which is arranged on the first interconnection and which supplies first RF power;

20 a first matching circuit which is arranged on the first interconnection between the first electrode and the first RF power supply and which automatically performs input impedance matching relative to the first RF power;

25 an impedance setting section which is arranged on the first intersection and which sets a backward-direction impedance as an impedance against an RF

component input to the first electrode;

a second RF power supply which is arranged on the second interconnection and which supplies second RF power, the second RF power supply being capable of
5 changing a frequency of the second RF power;

a second matching circuit which is arranged on the second interconnection between the second electrode and the second RF power supply and which automatically performs input impedance matching relative to the
10 second RF power; and

a controller which supplies a control signal concerning a preset value of a frequency of the second RF power to the second RF power supply.

32. The apparatus according to claim 31, wherein
15 the impedance setting section has the backward-direction impedance which is a constant preset value.

33. The apparatus according to claim 31, wherein
the impedance preset unit comprises one or both of an arrangement which continuously changes the backward-direction impedance with a continuous variable element,
20 and an arrangement which changes the backward-direction impedance stepwise by switching a plurality of fixed elements.

34. A calibration method for the impedance setting section in the apparatus according to claim 1, the
25 method comprising steps of:

obtaining, by measurement, calibration data that

compensates for a difference in setting the backward-direction impedance which is intrinsic to the impedance setting section; and

5 adjusting the preset value with the calibration data and then adjusting the backward-direction impedance.

35. The method according to claim 34, further comprising steps of:

10 obtaining, with a reactance measurement unit, a correlation between the preset value and a reactance of the impedance setting section against the RF component; and

15 obtaining the calibration data on the basis of a predetermined reference correlation and the obtained correlation.

36. The method according to claim 35, wherein the impedance setting section is connected to the first electrode, and the RF component has a frequency of the RF power to be applied to the second electrode, or
20 a frequency that largely influences a distribution of the plasma.

37. The method according to claim 35, wherein the reactance measurement unit is connected to an output terminal of the impedance setting section.

25 38. The method according to claim 35, wherein the impedance setting section is connected to the first electrode in the apparatus, and the reactance

measurement unit is connected to the first electrode in the method.

39. The method according to claim 34, wherein
the impedance setting section is connected to
5 the first electrode in the apparatus, and
the method comprises steps of
obtaining a correlation between a first parameter
and the preset value, the first parameter representing
information selected from the group consisting of a
10 voltage amplitude of an RF power applied to the first
electrode, an adjustment value of a matching circuit
connected to the first electrode, a voltage amplitude
of an RF power applied to the second electrode,
an adjustment value of a matching circuit connected to
15 the second electrode, and an output from an end point
detection spectroscope, and
obtaining the calibration data on the basis of
a predetermined reference correlation and the obtained
correlation.

20 40. The method according to claim 39, wherein the
controller automatically changes the backward-direction
impedance of the impedance setting section, so that
data concerning a change in the first parameter is
acquired, thus obtaining the calibration data.